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MILITARY POTENTIAL TEST OF A THREE-AXIS STABILITY AUGMENTATION --ETC(U)
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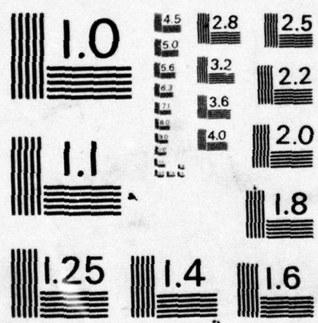

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US ARMY TEST & EVALUATION COMMAND

USATECOM PROJECT NO. 4-3-4250-01
RDT&E PROJECT NO. NONE
AD

Final Report of Test
"MILITARY POTENTIAL TEST OF A THREE-AXIS STABILITY AUGMENTATION SYSTEM/ DIRECTIONAL CONTROL SYSTEM"

Earl B. Smith

11 AUG 1965

US ARMY VIATION TEST BOARD
FORT RUCKER, ALABAMA

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MILITARY POTENTIAL TEST OF A THREE-AXIS STABILITY AUGMENTATION SYSTEM/ DIRECTIONAL CONTROL SYSTEM.

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9 Final ~~Report~~ of Test
Sep 64 - Jun 65

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DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

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ABSTRACT

The US Army Aviation Test Board conducted a military potential test of the three-axis SAS/DCS to determine whether it had sufficient military potential to warrant further Army interest. The SAS/DCS was installed in an unarmed UH-1B Helicopter and tested during the conduct of missions requiring a utility helicopter, in the vicinity of Fort Rucker, Alabama, from September 1964 through June 1965. The SAS/DCS was a significant aid in performing most of the missions but was unsatisfactory for some armament missions. The SAS mode was reliable during the test but the DCS was unreliable as a result of several malfunctions. It was concluded that the three-axis SAS/DCS has sufficient military potential to warrant further Army interest and that the deficiencies must be corrected. It was recommended that the deficiencies and shortcoming be corrected and that the three-axis SAS/DCS be service tested on an armed UH-1B Helicopter.

FOREWORD

1. Authority.

Letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 29 April 1963, subject: "Directive for Military Potential Test of Stability Augmentation System (SAS), USATECOM Project No. 4G-3425-( )," as revised by letter, AMSTE-BG, Headquarters, US Army Test and Evaluation Command, 15 May 1963, subject: "Revision of Test Directive for Military Potential Test of Stability Augmentation System (SAS)."

2. References.

a. Report of Project No. AVN 457.4, "Service Test of Automatic Stabilization for the H-34 Helicopter," US Army Aviation Board, November 1957.

b. Report of Test, Project No. AVN 560, "Service Test of the Automatic Flight Control System AN/ASW-12(V) Installed in an H-21 Helicopter," US Army Aviation Board, 13 September 1961.

c. TM 55-1520-208-10, "Operator's Manual, UH-1B Helicopter," Department of the Army, September 1961.

d. TM 11-6615-204-35, "Maintenance Manual, Automatic Flight Control System AN/ASW-12(V)," Department of the Army, March 1962.

e. TM 11-6615-204-12-C3, "Operator's Manual, Automatic Flight Control System AN/ASW-12(V)," Department of the Army, April 1962.

f. Letter, file 1730-CF.1-PH 1929, Sperry Phoenix Company, 14 December 1962, subject: "SAS Consignment Offer."

g. Letter, SELRA/I 37370500107, US Army Electronics Research and Development Laboratory, 29 March 1963, subject: "Sperry Consignment and 'Rudder Pedal Fix' for OV-1 Aircraft," with 1st Indorsement, Headquarters, US Army Electronics Command, 19 April 1963.

h. Letter, SELRA/SRI, US Army Electronics Research and Development Laboratory, May 1963, subject: "Evaluation of Stability Augmentation System for Lightweight Stability Augmentation System."

i. Report of Test, USATECOM Project No. 4-3-3400-01-G, "Service Test of the Yaw-Axis Channel of the Automatic Flight Control System, AN/ASW-12(V) Installed in UH-1B Helicopter for Use with the SS-11 System," US Army Aviation Test Board, May 1963.

j. Engineering Bulletin, "Installation of the AN/ASW-12(V) 3-Axis Damper and Heading Lock Control System for the UH-1B Helicopter," January 1964.

k. Plan of Test, USATECOM Project No. 4-3-4250-01, "Military Potential Test of Stability Augmentation System (SAS)," US Army Aviation Test Board, 30 March 1964.

l. Message, AMCPM-IRFO-T(A)-05-13329, Commanding General, US Army Materiel Command, "Safety-of-Flight Release for Testing of Sperry Three-Axis Stability Augmentation System (SAS) Installed in UH-1B Helicopter," May 1964.

m. Publication No. LJ-1252-0364A, "Design and Installation of the UH-1B Three-Axis Stability Augmentation/Directional Control System," Sperry Phoenix, June 1964.

n. Publication No. LJ-1252-0373, "UH-1B Three-Axis Stability Augmentation/Directional Control System, Flight Test Report," Sperry Phoenix, August 1964.

o. Publication No. LJ-60-0036, "Applications of AN/ASW-12(V) Automatic Flight Control System Components," Sperry Phoenix, September 1964.

p. Message, STEBG-TP-V 12-64, President, US Army Aviation Test Board, 31 December 1964, subject: "USATECOM Project No. 4-3-4250-01, MP Test of Stability Augmentation System."

q. Publication No. LJ-1253-0472, "UH-1B Three-Axis Stability Augmentation/Improved Directional Control System Flight Test Report," Sperry Phoenix, April 1965.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY AVIATION TEST BOARD
Fort Rucker, Alabama 36362

FINAL REPORT OF TEST

"MILITARY POTENTIAL TEST OF A THREE-AXIS STABILITY AUGMENTATION SYSTEM/ DIRECTIONAL CONTROL SYSTEM"

USATECOM PROJECT NO. 4-3-4250-01

Table of Contents

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SECTION 1

GENERAL

GENERAL

1.1. OBJECTIVES.

1.1.1. Purpose.

To determine whether the Stability Augmentation System/ Directional Control System (SAS/DCS) has sufficient military value to warrant further Army interest.

1.1.2. Test Objectives.

To determine:

a. Physical characteristics

b. Power requirements

c. Installation requirements

d. Safety features

e. Operational suitability

f. Operational reliability

g. Training requirements

h. Maintenance and support requirements

1.2. RESPONSIBILITIES.

1.2.1. The US Army Aviation Test Board (USAAVNTBD) was responsible for:

a. Performing such operational tests and other tasks as are required to determine the military value of the system.

b. Preparing and publishing the plan and report of test.

1.2.2. The US Army Aviation Test Activity (USAAVNTA) was responsible for:

a. Reviewing available engineering and test data concerning the SAS installation to determine whether all necessary flight qualification testing had been accomplished.

b. Conducting such flight testing as required to qualify the SAS installation prior to release for operational tests.

c. Assisting as appropriate in the preparation of the plan and report of test.

1.2.3. The US Army Electronics Research and Development Laboratory (USAERDL) was responsible for:

a. Coordinating and supervising the installation and removal of SAS by Sperry Phoenix Company personnel.

b. Providing the USAAVNTBD with funds to cover the cost of the program.

1.3. DESCRIPTION OF MATERIEL.

The three-axis SAS/DCS is an automatic stabilization system designed primarily for the UH-1B Helicopter. The system is designed to enhance the capability of the helicopter for weapon firing and for observation, cargo hauling, and general utility missions.

1.3.1. The test item has two basic modes of operation:

a. SAS: pitch, roll, and yaw

b. SAS/DCS: SAS and a heading hold

These modes of operation can be selected and operated by either the pilot or copilot.

1.3.1.1. While operating in the SAS mode, the system is designed to stabilize the helicopter around an established attitude on a short-term basis.

1.3.1.2. In the SAS/DCS mode of operation, the system is designed to provide long-term heading-hold stability and short-term stability in the roll and pitch axes.

1.3.2. The system consists of three limited-authority, light, automatic actuators connected in series with the respective controls. The attitude signal for the roll and pitch axes is obtained from the GH-211 gyro horizon, and the heading signal for the yaw stabilization is obtained from the S3A directional gyro.

1.3.3. The authority of the actuators is 10 percent in roll and pitch, and 25 percent in yaw.

1.4. <u>BACKGROUND.</u>

1.4.1. In December 1962, the manufacturer submitted to the USAERDL an unsolicited proposal (reference f) for a three-axis SAS for the UH-1B Helicopter. The SAS/DCS is designed to replace the single-axis AN/ASW-12(V) Automatic Flight Control System (AFCS) and is designed to improve the handling qualities of the helicopter.

1.4.2. In April 1963, the US Army Electronics Command (USAECOM) requested that the US Army Test and Evaluation Command (USATECOM) flight test the SAS (reference g).

1.4.3. Installation and flight-safety demonstrations were performed by the manufacturer under the supervision of USAERDL.

1.4.4. A safety release was provided by the US Army Materiel Command (USAMC) in May 1964 (reference l).

1.4.5. The helicopter with the system installed was delivered to the USAAVNTBD and the test began in September 1964.

1.5. <u>FINDINGS.</u>

1.5.1. <u>Physical Characteristics.</u>

The system components were at various locations in the helicopter. The total weight of the system was 25.41 pounds. Volume was not considered significant. The components were of small size and were mounted with the control-rod assemblies and in space which is not utilized for other purposes.

1.5.2. Power Requirements.

Maximum power requirements were 4.2 amperes at 28 volts d.c. and 86 v.-a. at 115 volts a.c. Ample power was available from the helicopter's power supply source.

1.5.3. Installation Requirements.

There were no unusual installation requirements. The diagrams and drawings furnished by the manufacturer were sufficient for the evaluation.

1.5.4. Safety Features.

The system's "disengage" operation and fail-safe features performed their intended functions.

1.5.5. Operational Suitability.

1.5.5.1. The three-axis SAS mode of operation was a significant aid in performing most missions.

1.5.5.2. The SAS/DCS was an aid in instrument and level flights as well as sling loading and rappelling operations, but was occasionally unreliable during hovering flights and simulated armament missions.

1.5.6. Operational Reliability.

The DCS was unreliable during the test period, whereas the SAS mode was satisfactory. The deficiencies are listed in appendix II.

1.5.7. Training Requirements.

1.5.7.1. No special training other than an orientation flight was required for the pilot to operate the system.

1.5.7.2. Organizational, direct, and general support maintenance could be performed by Army Aviation Electronic Equipment Repairmen, MOS 31Q20 (284.1) and 31Q30 (284.2) with formal training in maintaining the AN/ASW-12(V) AFCS, after approximately eight hours of on-the-job training.

1.5.8. Maintenance Requirements.

1.5.8.1. A rotary-wing mechanic, MOS 67P20 (675.30), would be required to install and remove the actuators contained in the control systems.

1.5.8.2. Tool kits, TK-87/U and TK-88/U, were adequate for organizational and field maintenance. The test equipment used in maintaining the AN/ASW-12(V) was sufficient for maintaining the system.

1.5.8.3. Some components have been standardized by the Army and are used with the AN/ASW-12(V) AFCS.

1.6. CONCLUSIONS.

1.6.1. The three-axis SAS/DCS has sufficient military potential to warrant further consideration for Army use.

1.6.2. The deficiencies listed in appendix II must be corrected.

1.6.3. Correction of the shortcoming listed in appendix II would enhance the suitability of the system.

1.7. RECOMMENDATION.

It is recommended that the deficiencies and shortcoming listed in appendix II be corrected and that the three-axis SAS/DCS be service tested on an armed UH-1B Helicopter.

SECTION 2

DETAILS AND RESULTS OF SUBTESTS

DETAILS AND RESULTS OF SUBTESTS

2.0. INTRODUCTION.

2.0.1. The Stability Augmentation System/Directional Control System (SAS/DCS) installed in a UH-1B Helicopter was evaluated by the USAAVNTBD during the period September 1964 - June 1965. The test item was flight tested for approximately 125 hours in the vicinity of Fort Rucker, Alabama, Fort Benning, Georgia, and Yuma, Arizona. The manufacturer of the system provided maintenance support during the evaluation.

2.0.2. Reports of previous tests of stability augmentation systems and the single-axis AN/ASW-12(V) were researched by project personnel prior to conduct of this test.

2.1. PHYSICAL CHARACTERISTICS.

2.1.1. Objective.

To determine size, weight, and any unusual physical characteristics of the system.

2.1.2. Method.

Dimensions and weight of the system were furnished by the manufacturer. The system was inspected as installed for any unusual characteristics.

2.1.3. Results.

2.1.3.1. The size and weight of the system's components furnished by the manufacturer were as follows:

Component	Length x Width x Height (in.)	Weight (lb.)
Attitude reference control	7 1/2 x 5 1/8 x 3 1/2	2.37
Directional control panel	6 9/32 x 3 1/64 x 5 25/32	1.50

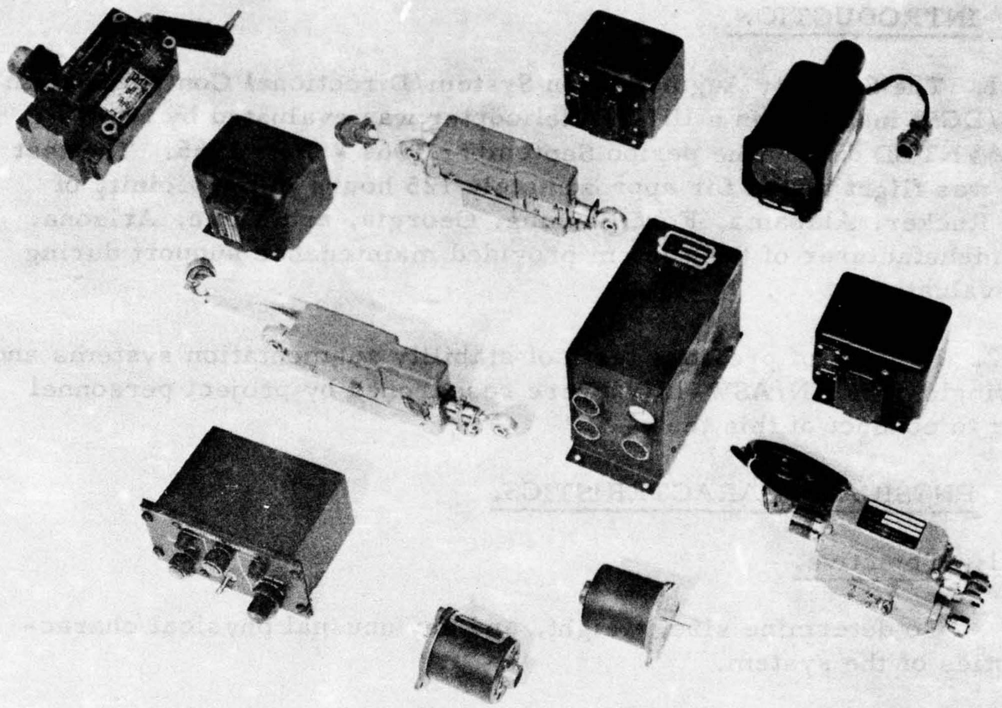

Figure 1. Components of the three-axis SAS/DCS

Component	Length x Width x Height (in.)	Weight (lb.)
Magnetic brake trim servo	6 x 3 x 1 3/4	4.87
Trim servo amplifier	5 3/32 x 3 1/32 x 4 1/32	1.00
Electro-hydraulic linear actuator (EHLA)	6 3/4 x 3 5/6 x 2 11/16	3.18
Roll electro-mechanical linear actuator (EMLA)	10 3/4 x 3 3/32 x 1 5/8	2.25
Pitch electro-mechanical linear actuator (EMLA)	10 3/4 x 3 3/32 x 1 5/8	2.25
Servo controller (EMLA)	4 15/32 x 4 1/32 x 4 3/16	1.06
Servo controller (EMLA)	4 15/32 x 4 1/32 x 4 3/16	1.06
Servo controller (EMLA)	4 15/32 x 4 1/32 x 4 3/16	1.06
Rotary-motion transducer (2 each)	2 3/16 x 2 13/16 x 3 3/64	0.56
Airspeed switch	1 27/32 x 1 1/2 x 3 3/8	0.25
Calibration units (actuator) (3 each)	2 19/32 x 1 25/32 x 1 25/32	0.75
Calibration units (trim)	2 19/32 x 1 25/32 x 1 25/32	0.25
GH-211 Attitude Indicator	6 3/4 x 3 1/6 x 3 1/6	3.00
TOTAL WEIGHT		25.41

2.1.3.2. No unusual characteristics were noted on the system.

2.1.3. Analysis.

The GH-211 attitude indicator replaced the standard copilot's gyro horizon and the combination magnetic brake and trim servo replaced the existing standard yaw magnetic brake. This reduces the net weight added to the helicopter to 20.7 pounds, as opposed to a system weight of 25.41 pounds.

2.2. POWER REQUIREMENTS.

2.2.1. Objective.

To determine power requirements of the system.

2.2.2. Method.

The a.c. and d.c. power requirements were measured in stand-by condition and in the SAS and DCS modes of operation.

2.2.3. Results.

2.2.3.1. The power requirements were as follows:

D.C. -	stand-by condition	0.5 a.	28 volts d.c.
	SAS operation	3.0 a.	28 volts d.c.
	DCS operation	4.2 a.	28 volts d.c.

A.C. -	stand-by condition	86 v.-a.	at 115 volts a.c.
	SAS operation	83 v.-a.	at 115 volts a.c.
	DCS operation	83 v.-a.	at 115 volts a.c.

2.2.3.2. Maximum power requirements from the helicopter's power supply source were 4.2 amperes at 28 volts d.c. and 86 v.-a. at 115 volts a.c.

2.2.3. Analysis.

Sufficient power was available from the helicopter to operate the test items.

2.3. INSTALLATION REQUIREMENTS.

2.3.1. Objective.

To determine adequacy of installation drawings and diagrams provided by the manufacturer and any unusual requirements for installation.

2.3.2. Method.

The manufacturer's installation requirements, drawings, and diagrams were examined for adequacy and for any unusual requirement for installation.

2.3.3. Results.

2.3.3.1. The drawings and diagrams of the system's installation were adequate for the evaluation.

2.3.3.2. No unusual installation requirements were noted.

2.3.3.3. Figures 2 and 3 show wiring and component installations of the system.

2.3.4. Analysis.

Not applicable.

2.4. SAFETY FEATURES.

2.4.1. Objective.

To determine the safety features of the SAS/DCS.

2.4.2. Method.

The system was examined for the adequacy of the system-disengage function feature, fail-safe features, and warning devices in event of malfunctions. During actual operations, safety features were operated and evaluated.

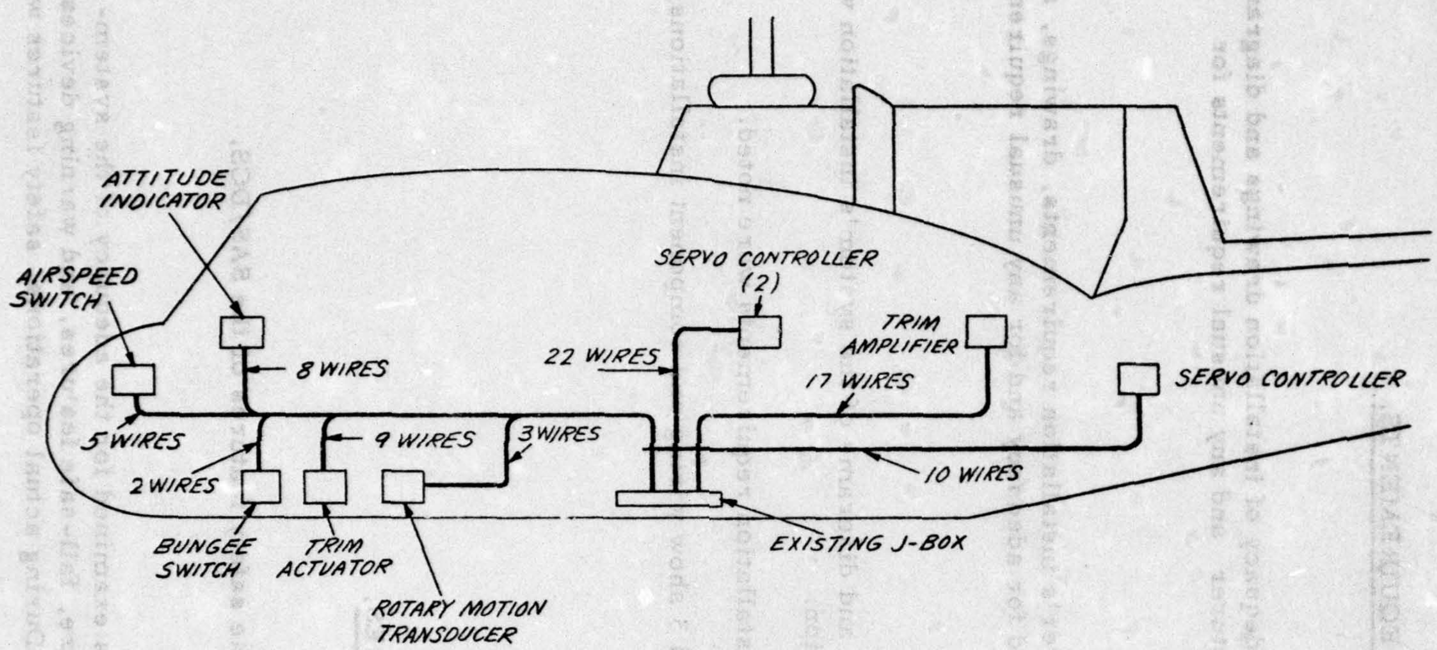

Figure 2. System wiring for three-axis SAS/DCS

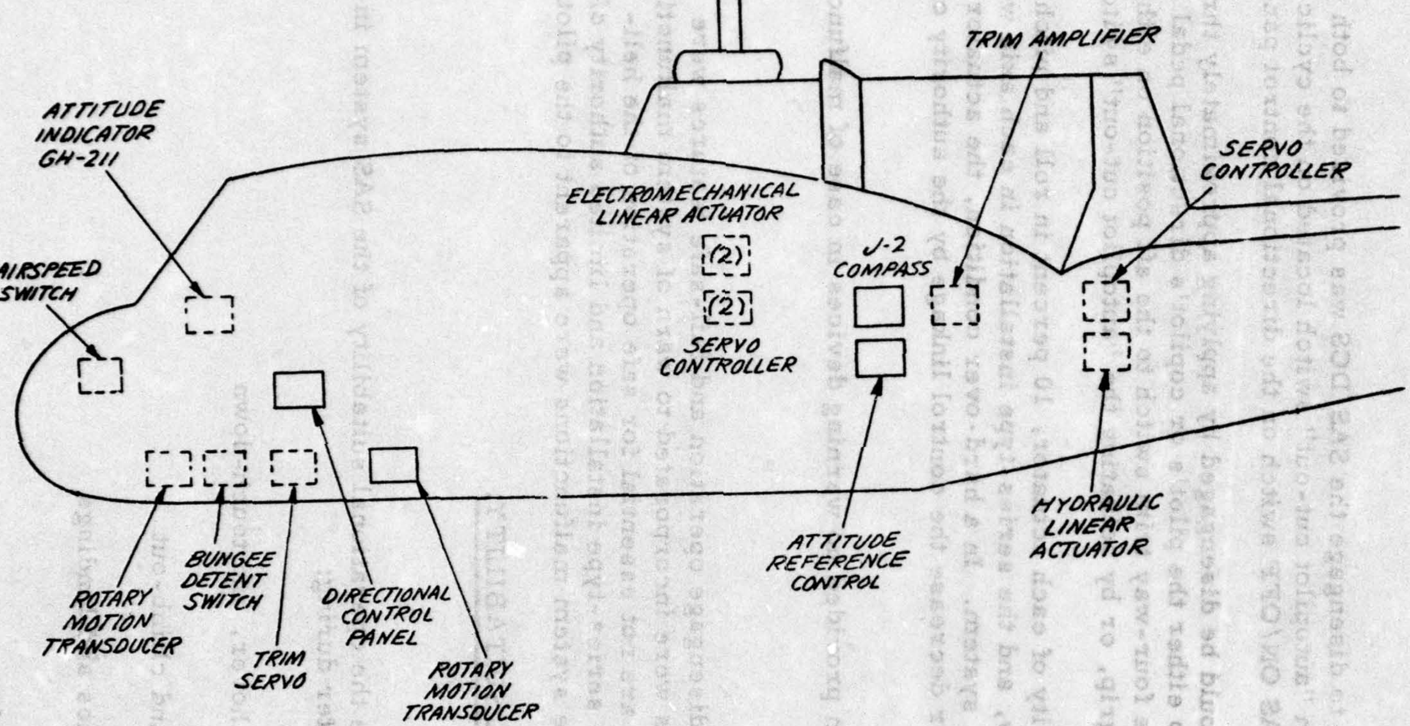

Figure 3. Location in UH-1B of components of the SAS/DCS

2.4.3. Results.

2.4.3.1. The ability to disengage the SAS/DCS was provided to both pilot and copilot through an "autopilot cut-out" switch located on the cyclic-stick grips and the SAS ON/OFF switch on the directional control panel.

2.4.3.2. The DCS could be disengaged by applying approximately three pounds of pressure to either the pilot's or copilot's directional pedal controls, by pressing the four-way trim switch to the aft position on either cyclic-stick control grip, or by actuating the "autopilot cut-out" switch.

2.4.3.3. The authority of each actuator, 10 percent in roll and pitch and 25 percent in yaw, and the series-type installation in each axis were safety features of the system. In a hard-over condition, the actuator could only increase or decrease the control linkage by the authority of the actuator.

2.4.3.4. The system provided no warning devices in case of malfunctions.

2.4.4. Analysis.

The system-disengage operation and fail-safe features were adequate. No devices were incorporated to warn of system malfunction or failure; such devices are not essential for safe operation of the helicopter because of the series-type installation and limited authority of the actuators and because system malfunctions were apparent to the pilot.

2.5. OPERATIONAL SUITABILITY.

2.5.1. Objective.

To determine the operational suitability of the SAS system installed in the helicopter during:

a. Lift-off, hover, and touch-down

b. Lift-off and climb-out

c. Approaches and landings

d. Level flights

e. Sling-load operations

f. Instrument flights

g. Armament flights

h. Rappelling and cargo operations

2.5.2. Method.

The helicopter with the system installed was flown by project pilots with flight experience of 50 to 2500 hours in UH-1 Helicopters throughout each of the maneuvers listed in 2.5.1. The tests were conducted in wind conditions varying from calm to peak gusts of 20 knots.

2.5.2.1. Lift-Off, Hover, and Touch-Down.

The helicopter was operated both in and out of ground effect with SAS/DCS off and with SAS on and DCS on and off in cross wind, down wind, and up wind.

2.5.2.2. Lift-Off and Climb-Out.

Normal, maximum performance, and running takeoffs and climb-outs were conducted with DCS off and SAS on and off.

2.5.2.3. Approaches and Landings.

Normal, steep, and running approaches were conducted with DCS off and SAS on and off.

2.5.2.4. Level Flights.

Level flights were conducted at airspeeds of 60, 70, 80, 90, and 100 knots with SAS/DCS off and with SAS on and DCS on and off. Hands-off flights were conducted to determine the automatic-flight characteristics.

2.5.2.5. Contour Flights.

Contour flights and nap-of-the-earth flights were conducted with DCS off and SAS on and off to note any restrictions imposed by the system.

2.5.2.6. Sling Loading.

Hook-up and sling-load operations were conducted using 1100- and 1500-pound loads of different sizes, with SAS/DCS off and with SAS on and off, and DCS on and off.

2.5.2.7. Instrument Flights.

Ground-controlled approaches (GCA) were conducted with SAS/DCS off and with SAS on and DCS on and off.

2.5.2.8. Armament Flights.

Simulated armament missions with the helicopter in a clean configuration of grazing fire, bobbing fire, hovering fire, low-level running fire, and straight and level runs were conducted with SAS/DCS off and with SAS on and DCS on and off.

2.5.2.9. Rappelling and Cargo Operations.

The helicopter was operated with SAS/DCS off and with SAS on and DCS on and off during personnel descents and cargo lifting and lowering at hovering altitudes of 30 to 150 feet.

2.5.3. Results.

2.5.3.1. Lift-Off, Hover, and Touch-Down.

2.5.3.1.1. Using the SAS resulted in significant improvement when the helicopter was hovered in and out of ground effect and into a cross wind and down wind position. During cross wind hovers with SAS off, movements about the roll axis were encountered; by engaging the SAS, the movements were minimized. In down wind hovering with SAS off, the helicopter would pitch down and roll, requiring considerable correction by the pilot; with SAS engaged, corrections by the pilots were reduced to approximately one half. With the SAS/DCS (heading-lock) engaged, it was possible to hold the desired heading without pilot inputs to the controls. However, in one operation during hover in and out of ground effect, the DCS lost lock, causing a fast turn of 120 degrees before the pilot regained control of the helicopter. During lift-off, the helicopter had to be light on its skids and then lifted up slowly to prevent losing lock and going into a right turn.

2.5.3.1.2. The manufacturer modified the system in an attempt to correct the malfunctions of the DCS. The modification resulted in some improvements but did not correct the lift-off problem.

2.5.3.2. Lift-Off and Climb-Out.

During normal, maximum performance, and running takeoffs and climb-outs without the SAS engaged, the helicopter was subjected to continuous yawing and rolling actions. When the SAS was engaged, these movements were minimized and the helicopter would maintain the roll, pitch, and yaw attitudes established by the pilot.

2.5.3.3. Approaches and Landings.

During normal, steep, and running approaches and during landings with the SAS off, yawing actions were encountered and pilot inputs normally resulted in over-corrections. With the SAS on, the common problem of over-correcting with the pedal was minimized. The extent to which the SAS provided assistance to the pilot was considered significant in the yaw axis and was noticeable in roll and pitch.

2.5.3.4. Level Flights.

2.5.3.4.1. During level flights with the SAS off in calm conditions, the helicopter had continuous yawing motions. With SAS engaged, the motions were eliminated. During operations in turbulent conditions without the SAS engaged, pilot inputs were continuous and usually resulted in over-correcting. With the system engaged, less pilot input was required and over-corrections were eliminated.

2.5.3.4.2. With the SAS/DCS engaged, it was possible to fly hands-off controls for periods of 5-10 minutes. At speeds below 80 knots, yawing actions occurred; above speeds of 80 knots, the yawing actions decreased.

2.5.3.5. Contour Flights.

No significant improvement was noted during contour flights with SAS on as compared to those with SAS off. However, no restrictions were imposed on the flight envelope of the helicopter with SAS on.

2.5.3.6. Sling Loads.

2.5.3.6.1. The SAS/DCS was a significant aid during hook-up and release of the load. With SAS/DCS on, it was possible to hover over the load, hook-up, and liftoff without any inputs to the control pedals.

2.5.3.6.2. The SAS provided a significant improvement in stabilization of the roll and yaw axes of the helicopter while in flight with loads. During turns with SAS off, the load caused the helicopter to move about the roll axis. When an attempt was made to stabilize the control stick to a center position, oscillations increased; after SAS was engaged, the helicopter stabilized itself with little pilot input.

2.5.3.7. Instrument Flights.

The SAS/DCS provided significant aid to the pilot while making GCA approaches. Small heading changes between 1 and 10 degrees requested by the Ground Controller could be made accurately by beeping the DCS. Larger heading changes required releasing heading-lock, establishing the new heading, and re-engaging the DCS.

2.5.3.8. Armament Flights.

The SAS provided assistance to the pilot during simulated armament missions; however, the DCS was unsatisfactory in some maneuvers.

2.5.3.8.1. During bobbing fire, the DCS would momentarily lose heading and turn the helicopter to the right approximately 30 degrees before returning to the original heading. This occurred when the helicopter ascended or descended rapidly.

2.5.3.8.2. During grazing and hover-fire flights, engagement of the DCS with the helicopter in a flat turn resulted in 10- to 15-degree overshoots about the desired heading before the helicopter stabilized.

2.5.3.8.3. If a flare was executed during low-level firing flights with the DCS engaged, the helicopter would turn approximately 90 degrees. A modification of the system by the manufacturer decreased the degree of turn in flares to approximately 15 degrees.

2.5.3.8.4. During straight and level flights at speeds from 80 to 100 knots, the SAS/DCS was satisfactory and the target could be held to

a great degree of accuracy with only pilot inputs to the "beep" trim switch. At lower airspeeds of 50 to 80 knots with both SAS and DCS engaged, small, abrupt yawing oscillations occurred.

2.5.3.9. <u>Rappelling and Cargo Operations.</u>

2.5.3.9.1. With the SAS off during personnel descents, continuous control movements were required to stabilize the helicopter. This occurred while the troops were leaving the helicopter and again while the descending troop applied individual braking action. With the SAS on, smaller inputs were required by the pilot for stabilization; with the SAS/DCS on, it was possible to maintain a stabilized platform with little control movement by the pilot.

2.5.3.9.2. With the SAS off, severe oscillations were experienced during rappelling operations with cargo loads and during liftoff, and large pilot control inputs were required for stabilization. With the SAS on, fewer inputs were required; with SAS/DCS on, heading could be maintained as the helicopter lifted to the desired altitude.

2.5.3.9.3. When cargo was lowered with the SAS off, the pilot experienced difficulty attempting to stabilize the helicopter and could not maintain heading. With SAS on, stabilizing the helicopter was less difficult; with SAS/DCS on, the heading was maintained without difficulty.

2.5.4. <u>Analysis.</u>

2.5.4.1. The SAS was a significant aid during most of the test maneuvers.

2.5.4.2. The DCS aided in instrument flights, sling loading, rappelling and cargo operations, and level flights but was unsatisfactory in lift-off to a hover and for some armament missions.

2.6. OPERATIONAL RELIABILITY.

2.6.1. <u>Objective.</u>

To determine the operational reliability of the SAS/DCS during the test period.

2.6.2. Method.

The system was evaluated for approximately 125 flight hours. The performance of the system was recorded and malfunctions occurring were reported to the manufacturer's representative for corrective action.

2.6.3. Results.

Eleven malfunctions occurred in the test item requiring suspension of the test (reference p) and some component modification by the manufacturer. The modifications were partially successful, eliminating some malfunctions and improving operation. A list of malfunctions and maintenance performed by the manufacturer during the evaluation may be found in appendix I.

2.6.4. Analysis.

The DCS mode was unreliable during the test period, whereas the SAS maneuver mode operated satisfactorily. The unsatisfactory conditions still existing after modification are listed as deficiencies in appendix II.

2.7. TRAINING REQUIREMENTS.

2.7.1. Objective.

To determine training requirements for operator or maintenance personnel.

2.7.2. Method.

Manufacturer's operating and maintenance instructions were evaluated for complexity and time requirements.

2.7.3. Results.

2.7.3.1. No special training was required for the operator. The operator became proficient in the operation of the system during a brief orientation flight.

2.7.3.2. Organizational, direct support, and general support maintenance of the system could be performed by Army Aviation Electronic

Equipment Repairmen, MOS 31Q20 and 31Q30, with formal training in the AN/ASW-12(V) AFCS or experience after approximately eight hours of on-the-job training.

2.7.3.3. A rotary-wing mechanic, MOS 67P20, would be required to remove and install the actuator and would require only a short briefing on the location and operation of the components.

2.7.4. Analysis.

Not applicable.

2.8. MAINTENANCE REQUIREMENTS.

2.8.1. Objective.

To determine how well the system meets the standards of present maintenance and support systems.

2.8.2. Method.

Maintenance and repair operations of the system were performed by manufacturer's representatives. Maintenance operations were observed and evaluated using AR 750-6 as a guide.

2.8.3. Results.

No maintenance package was furnished for the evaluation.

2.8.3.1. Ease of Maintenance.

The manufacturer repaired the components of the system as required at the factory and this repair was not observed by avionic maintenance personnel. The installation and removal of components posed no unusual problems.

2.8.3.2. Test Equipment.

2.8.3.2.1. No special test equipment was required. The AN/ASM-80/AN/ASW-12 autopilot flight-line analyzer was sufficient for flight-line testing of the system. The test item could not be bench tested with the AN/ASM-125 bench test set without modifications to the test set.

2.8.3.2.2. The EMLA and EHLA would require repair by the manufacturer.

2.8.3.3. Tool Kits.

The TK-87/U and TK-88/U tool equipment sets were adequate for organizational, direct support, and general support maintenance.

2.8.3.4. Parts Standardization.

The rotary-motion transducers, attitude-reference controller, and directional-control panel are standard AN/ASW-12 AFCS components. The other components are non-standard and would be obtainable from the manufacturer.

2.8.3.5. Technical Publications.

The technical publications furnished by the manufacturer were not in the standard Army format and were considered inadequate for Army use.

2.8.4. Analysis.

2.8.4.1. The system met to a satisfactory degree the standards of present maintenance and support systems except that adequate technical publications must be provided in the Army format prior to introduction of the item into the test system.

2.8.4.2. The AN/ASM-125 bench test set with modification will be suitable for bench testing of the components.

SECTION 3

APPENDICES

APPENDIX I - TEST DATA

Malfunction	Maintenance Performed by the Manufacturer
a. Helicopter oscillated about yaw axis in SAS and SAS/DCS.	Electro-hydraulic linear actuator removed and repaired (35 hours).
b. Helicopter jerked in yaw axis while engaging the SAS in turn.	Ground-checked o.k. (8 hours).
c. Helicopter turned right to approximately 120 degrees while in hover with heading-lock engaged.	Computer studies and modification made at factory (reference q).
d. System lost heading-lock while banking helicopter in hover.	Computer studies and modification made at factory (reference q).
e. Fast 90-degree turn to right while performing maximum-performance take-off from hover with heading-lock engaged.	Computer studies and modification made at factory (reference q).
f. Helicopter turned right to 90 degrees while making flares from low-level flights with heading-lock engaged.	Computer studies and modification made at factory (reference q).
g. Violent lateral jerking while SAS was engaged with yaw-control pedals displaced.	Computer studies and modification made at factory (reference q).
h. Heading over-shot $\pm$ 10 to 15 degrees when heading-lock was engaged with helicopter in heading drift.	Computer studies and modification made at factory (reference q).

Malfunction	Maintenance Performed by the Manufacturer
i. Roll and pitch SAS was inoperable.	Hydraulic fluid from boost actuators accumulated in EMLA. Replaced actuators and installed "boots" between boost and EMLA actuators.
j. Heading-lock would not stay engaged in turbulent weather.	Cleaned bungee-detent switch.

APPENDIX II

DEFICIENCIES AND SHORTCOMING

A. Deficiencies. The following deficiencies were discovered during the conduct of test:

Deficiency	Suggested Corrective Action	Remarks
1. Heading-hold was lost intermittently while the helicopter was lifted up in maximum takeoff.	Design system to hold heading during maximum-performance takeoff.	
2. Small abrupt yawing action occurred in level flight at airspeeds below 80 knots.	Design system to eliminate yawing action at all helicopter speeds.	
3. Yaw oscillations occurred when heading-lock was engaged while helicopter was in heading drift.	Design system to prevent yaw oscillations.	
4. Hydraulic fluid accumulated in roll and pitch actuators, making them inoperable.	Design actuator to prevent being contaminated with fluid.	A rubber boot was installed between the boost actuator and roll and pitch actuators to prevent fluid flow.
5. Helicopter diverged to right approximately 15 degrees while making flareouts with heading-lock engaged.	Design DCS system to eliminate divergence while executing flares.	The system, before modification, would diverge to 90 degrees in flares.

Deficiency	Suggested Corrective Action	Remarks
6. The technical publications were inadequate.	Provide adequate technical publications in the standard Army format.	

B. Shortcoming. The following shortcoming was discovered during the conduct of test:

Shortcoming	Suggested Corrective Action	Remarks
The system could not be bench tested with the AN/ASM-125 bench test set without minor modifications of the test set.	None	

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